



TRANSLATION OF JAPANESE PATENT NO. 54-30590

SPECIFICATION

1. Title of the Invention

METHOD OF CUTTING OPTICAL FIBER AND CUTTING DEVICE
THEREFOR

2. Claims for Patent

1. A method of cutting an optical fiber characterized by moving any one of a laser beam emitted from a CO₂ laser light source corresponding to a heat source and an optical fiber holding device, focusing said laser beam, applying a thermal stress to a micro local area of the optical fiber by traversing above the optical fiber at a fixed speed in a vertical direction to an axis of the optical fiber, and thereafter cutting the optical fiber by pulling the optical fiber in an axial direction.

2. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a lens holding device provided for holding the lens and capable of moving in a three-dimensional direction, and an optical fiber cutting jig holding the optical fiber to be cut and pulling the optical fiber in an axial direction by a suitable tensile force.

3. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a fixed lens holding device provided for holding the lens, and an optical fiber cutting jig holding the optical fiber to be cut and having a moving function of moving the optical fiber at a fixed speed in a vertical direction to an axis of the optical fiber in this state

and a function of pulling the optical fiber in an axial direction by a suitable tensile force.

4. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a lens holding device provided for holding the lens and capable of moving in a three-dimensional direction, and an optical fiber cutting jig holding a lot of optical fibers to be cut in such a manner that a parallel relation is established, and having a function of simultaneously pulling the optical fibers in an axial direction of the optical fibers by a suitable tensile force.

5. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a fixed lens holding device provided for holding the lens, and an optical fiber cutting jig holding a lot of optical fibers to be cut in such a manner that a parallel relation is established, and having a moving function of moving the optical fibers at a fixed speed in a vertical direction to an axis of the optical fibers in this state and a function of simultaneously pulling a lot of optical fibers in an axial direction by a suitable tensile force.

6. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a lens holding device provided for holding the lens and capable of moving in a three-dimensional direction, and an optical fiber cutting jig applying a

curvature to the optical fiber to be cut so as to hold the optical fiber and having a function of pulling the optical fiber in an axial direction of the optical fiber by a suitable tensile force in a state of applying the curvature.

7. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a fixed lens holding device provided for holding the lens, and an optical fiber cutting jig applying a curvature to the optical fiber to be cut so as to hold the optical fiber and having a moving function of moving the optical fiber at a fixed speed in a vertical direction to an axis of the optical fiber in this state and a function of pulling the optical fiber in an axial direction by a suitable tensile force.

8. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a lens holding device provided for holding the lens and capable of moving in a three-dimensional direction, and an optical fiber cutting jig holding a lot of optical fibers to be cut in a state of establishing a parallel relation to each other and applying a curvature and having a function of simultaneously pulling the optical fibers in an axial direction of the optical fibers by a suitable tensile force.

9. An optical fiber cutting device characterized in that the optical fiber cutting device is provided with a CO₂ laser light source corresponding to a heat source, a focusing lens for focusing and irradiating a laser beam emitted from the light source to a micro local area of the optical fiber, a fixed lens holding device provided for

holding the lens, and an optical fiber cutting jig holding a lot of optical fibers to be cut in a state of establishing a parallel relation to each other and applying a curvature and having a moving function of moving the optical fibers at a fixed speed in a vertical direction to an axis of the optical fibers in this state and a function of simultaneously pulling a lot of optical fibers in an axial direction of the optical fibers by a suitable tensile force.

3. Detailed Description of the Invention

The present invention relates to a method of cutting an optical fiber and a cutting device therefore which rapidly cut the optical fiber with a good perpendicularity.

It is one of important techniques required for achieving an optical communication system to cut an optical fiber so as to form a smooth and clean end surface having a good perpendicularity with improved reproducibility.

In conventional, as a method of forming the end surface of the optical fiber, there have been employed a method of scratching a part of the optical fiber by a cutter made of an aluminum or a diamond and thereafter pulling and cutting the optical fiber so as to form the end surface, and a method of forming the end surface in accordance with a series of steps comprising a cutting step, a rough grinding step and a grinding step. In these methods, the method of forming the end surface in accordance with the series of steps comprising the cutting step, the rough grinding step and the grinding step requires a lot of works, and has a defect that the method lacks a rapidity, and it is unavoidable that the end surface is contaminated by an abrasive material. Further, since the method of pulling and cutting the optical fiber after scratching by the diamond cutter or the like is hard to keep a pressure applied to the fiber at a time of scratching constant, there are defects that the reproducibility is deteriorated, the cut surface is hard to be perpendicular to a fiber axis, and

a processed surface is largely crushed.

On the other hand, a method using a laser beam which has been conventionally employed is a method of evaporating and removing a portion to be cut by a high-power laser, and is the same as a method of continuously piercing in principle. Accordingly, in the case that this method is applied to cutting of the optical fiber, there are defects that the perpendicularity of the end surface is deteriorated and a heat affected layer leaves in the periphery of the cut end surface.

The present invention is made for the purpose of removing the defects, and an object of the present invention is to provide a method of rapidly cutting an optical fiber smoothly with good perpendicularity and without accompanying contamination in an end surface, by setting a low-power (about 0.1 to 5 W) CO₂ laser to a heat source, irradiating a focused laser beam to an extremely micro local area of the optical fiber, inducing a great thermal stress accompanied by a rapid thermal gradient near the area, and thereafter pulling the optical fiber in an axial direction, and a cutting device therefore.

A description will be in detail given below of the present invention with reference to the accompanying drawings.

Fig. 1 is a view for explaining a principle of a method of cutting an optical fiber in accordance with the present invention.

In Fig. 1, a laser beam 2 from a CO₂ laser light source 1 is reflected by a reflecting mirror 3 and is focused by a lens 4. Reference numeral 5 denotes a shutter. As long as the shutter is open, a laser beam is taken out continuously. An optical fiber 6 is placed approximately at a focal point position of the focusing lens 4, and is in contact with a focused laser beam 7. The focused laser beam traverses the optical fiber at a fixed speed in a vertical direction to an axis of the optical fiber by moving the focusing lens 4 or the optical fiber 6. At this time,

a very large thermal gradient is generated in an extremely micro local area to which the focused laser beam is irradiated, and a thermal stress is induced. When thereafter pulling the optical fiber 6 in an axial direction shown by reference numerals 8 and 8', a crack is generated at a starting point constituted by a maximum point of the thermal stress, the crack is developed, and the optical fiber 6 is finally cut.

Fig. 2 is a perspective view of a first embodiment of an optical fiber cutting device in accordance with the present invention. The cutting device is provided with two left and right optical fiber holding devices 10 and 11, and one holding device 11 can slide on a guided metal fitting 12 mounted on a base plate 9.

An arm 13 is mounted to the holding device 11, and the arm 13 is fitted into a shaft 14 having a threaded groove. The arm 13 is structured such as to move right and left by turning a knob 15. Surfaces of the left and right holding devices 10 and 11 are coated by a resin such as Teflon or the like, thereby preventing the optical fiber from being scratched at a time of holding the optical fiber. Further, reference numerals 16 and 17 denotes Teflon plates. The optical fiber 6 is clamped and fixed between the Teflon plates 16 and 17 and the left and right holding devices 10 and 11 by fastening screws 18, 18', 18'', 19, 19' and 19''. A focusing lens holding device 20 can move in a three-dimensional direction, and is structured such that the focusing lens holding device 20 can move at a fixed speed in a vertical direction to an optical fiber axis shown by an arrow 21 by being communicated with a motor or the like via a pulley 22.

In this cutting device, the cutting step is executed in accordance with the following procedure.

First, the optical fiber element wire 6 is exposed by stripping a jacket in an end portion of the optical fiber by a wire stripper and removing a primary coating agent by an acetone or the like. Next, the optical fiber 6

clamped and fixed on the left and right holding devices 10 and 11 by biasing the holding device 11 to a left end to the maximum by the knob 15, loosening the screws 18, 18', 18'', 19, 19' and 19'', holding the fiber 6 between the Teflon plates 16 and 17 and the left and right holding devices 10 and 11, and fastening the screws 18, 18', 18'', 19, 19' and 19''. The shutter 5 of the CO₂ laser light source 1 is opened in this state, and the CO₂ laser beam is taken out to a cutting system. At this time, a height of the focusing lens 4 from a surface of the base plate is previously adjusted such that the optical fiber 6 is arranged approximately at the focal point position of the focusing lens 4. When moving the focusing lens holding device 20 at a fixed speed in any one direction of a arrow 21 by the motor, the focused laser beam traverses above the optical fiber 6 in the vertical direction to the axis. At this time, as is explained in Fig. 1, the rapid thermal gradient is generated in the optical fiber 6, and the thermal stress is induced.

In accordance with stopping the movement of the focusing lens holding device 20, turning the knob 15 and moving the holding device 11 to the right side, a greater tensile stress is applied to the optical fiber 6, a micro crack is generated at a starting point constituted by a maximum point of the thermal stress of the optical fiber 6 on the basis of the tensile stress, whereby the tensile stress is further increased, and when the tensile stress is equal to or more than a critical strength in the micro crack portion, the optical fiber 6 is cut.

Fig. 3 is a perspective view of a second embodiment. A base plate 24 having a guide 23 is fitted to a pedestal 25. A leading end of the guide 23 is formed as a rack (not shown), and the base plate 24 is structured such as to move at a fixed speed in a vertical direction to the axis of the optical fiber 6 by engaging a pinion gear (not shown) mounted to the pedestal 25 with the rack and rotating the pinion gear by the motor. In this embodiment, a focusing

lens holding device 26 is fixed to the pedestal 25, the base plate 24 alternatively moves, and the focused laser beam traverses above the optical fiber perpendicularly to the axial direction.

Figs. 4 and 5 are perspective views of third and fourth embodiments of the optical fiber cutting device in accordance with the present invention. Each of the embodiments can cut a lot of optical fibers all at once by holding a lot of optical fibers on the holding devices 10 and 11, traversing the focused laser beam above the optical fibers and thereafter pulling the optical fibers, as shown in Figs. 4 and 5.

Fig. 6 is a perspective view of a fifth embodiment of the optical fiber cutting device in accordance with the present invention, and Fig. 7 is a side elevational enlarged view of a part which applies a curvature to the optical fiber and holds the optical fiber.

In the cutting device shown in Fig. 6, a jig 27 for applying a curvature to a portion between the left and right holding devices 10 and 11 is placed, whereby it is possible to adjust a height of a metal fitting 28 having a curvature from the base plate 9 by means of a knob 29. As shown in Fig. 7, a center of the metal fitting 28 is formed as a cavity 30, whereby it is possible to prevent the heat absorbed by the optical fiber 6 from the irradiated laser beam from diffusing via the metal fitting 28, by irradiating the laser beam to this cavity portion.

A strength of the stress is distributed in a diametrical direction of the optical fiber by holding the optical fiber while applying the curvature. Accordingly, when irradiating the CO₂ laser beam in this state, it is possible to induce a thermal stress required for cutting on the basis of a comparatively small laser output. Even in the case of cutting the optical fiber while applying the curvature, it is possible to employ a method of moving the focusing lens holding device 20 and oscillating the laser beam as shown in Figs. 6 and 9 and a method of moving

the base plate 24 having the optical fiber holding devices 10 and 11 mounted thereon and moving the laser beam above the optical fiber in the vertical direction to the axis as shown in Figs. 8 and 10.

Figs. 9 and 10 are perspective views of seventh and eighth embodiments of the optical fiber cutting device in accordance with the present invention. As shown in Figs. 9 and 10, it goes without saying that a lot of optical fibers can be cut all at once by simultaneously holding a lot of optical fibers.

In this case, as the focusing lens used in the present invention, a spherical lens and a cylindrical lens may be employed, and are not different in effects.

As described above, since the method of cutting the optical fiber and the cutting device in accordance with the present invention employs the low-power CO₂ laser as the heating source, utilizes the thermal stress induced to the extremely micro local area without melding the optical fiber and cuts the optical fiber, the optical fiber is not molten and deformed, and the perpendicularity and the smoothness are improved, in comparison with the conventional case of cutting the optical fiber by melting by means of the high-power laser, so that it is very effective for obtaining a clean end surface. Further, since the output of the CO₂ laser can be easily controlled, there is an advantage that it is possible to carry out a cutting operation with extremely good reproducibility. Further, since the heat is applied while changing the relative position of the CO₂ laser beam and the optical fiber, it is possible to cut a lot of optical fibers all at once, so that there is an advantage that it is possible to extremely rapidly carry out the cutting operation.

Accordingly, the present invention is extremely effective by being applied to the cutting operation of the optical fiber in which a clean end surface is obtained rapidly, with good reproducibility, good perpendicularity and good smoothness.

4. Brief Description of the Drawings

Fig. 1 is a view for explaining a principle of a method of cutting an optical fiber in accordance with the present invention, Figs. 2 to 6 are perspective views of respective first to fifth embodiments of an optical fiber cutting device in accordance with the present invention, Fig. 7 is a side elevational enlarged view of a portion which holds the optical fiber while applying a curvature in Fig. 6, Figs. 8 to 10 are perspective views of respective sixth to eighth embodiments of the optical fiber cutting device in accordance with the present invention.

1 ... CO₂ laser light source, 2 ... CO₂ laser beam, 3 ... reflecting mirror, 4 ... focusing lens, 5 ... shutter, 6 ... optical fiber, 7 ... focused laser beam, 8, 8' ... tensile force applying direction, 9 ... base plate, 10 ... left holding device, 11 ... right holding device, 12 ... guided metal fitting, 13 ... arm, 14 ... shaft, 15 ... knob, 16, 17 ... Teflon plate, 18, 18', 18'', 19, 19', 19'' ... screw, 20 ... focusing lens holding device, 21 ... motor driving direction of focusing lens, 22 ... pulley, 23 ... guide, 24 ... base plate, 25 ... pedestal, 26 ... focusing lens holding device, 27 ... jig for applying curvature, 28 ... metal fitting with curvature, 29 ... knob, 30 ... cavity.